COMPARATIVE EFFECTS OF ANIMAL PROTEINS ON GROWTH, PROTEIN UTILIZATION AND CONDITION FACTOR OF NILE TILAPIA, *Oreochromis niloticus*

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ABSTRACT

Study was conducted to evaluate animal proteins, either alone or in combination, on growth performance, nutrient utilization, condition factor and survival of male Nile tilapia *Oreochromis niloticus*. Four isonitrogenous diets (30% crude protein) were prepared, using spray-dried blood, fish, meat and bone meals as major protein sources in diets 1, 2 and 3, respectively, while diet 4 had an equal proportion (1:1:1) of the above protein sources. Triplicate groups of fish with mean initial weight and total length of 30.50g ±0.30 g and 12.20 ±0.12cm respectively were randomly stocked in 12 plastic troughs in closed water flow-through system provided with aeration device at 10 fish per trough. Fish weights were measured and the results used to compute growth parameters. Fish fed Diet 4, had significantly ($p < 0.05$) higher weight gain, specific growth rate and protein productive value compared to groups fed Diets 1, 2, and 3. There was no significant difference ($p > 0.05$) in food conversion and protein efficiency ratios between this fish and those fed pure fishmeal diet. Also, different protein sources in the diets did not significantly affect the body composition of the fish ($p > 0.05$) except for the condition factor. Comparison among different dietary protein sources on the growth, feed utilization and body composition of *Oreochromis niloticus* indicated that combination of fishmeal, blood meal, and meat and bone meal was more effective than any of the three protein sources alone.

INTRODUCTION

Tilapia is one of the most widely cultured fish in the world. Currently, farmed tilapia represents more than 75% of world tilapia production (FAO, 2009). Tilapia feed on a wide variety of dietary sources and adult tilapia are principally herbivorous but readily adapt to complete commercial diets based on plant and animal protein sources. Fishmeal has traditionally been a major ingredient in fish feed because of its high protein content, palatability and a balanced amino acid profile (Effiong, 2015). However, world fish meal production has remained relatively static at 6.2 million tonnes since 1997 and it is unlikely to increase (FAO, 2013). It is evident from these statistics that continued expansion of aquaculture will not be possible if fishmeal is relied upon as the main source of protein in aqua-feeds. Naylor *et al* (2000) noted that livestock feed contained only 2-3% fishmeal. However, 20 years ago, fishmeal was also the preferred source of protein for poultry feeds, just as is the case for some aquatic species today. Also, FIN (2006) reported that in channel catfish diets, fishmeal decreased from 8-10% in 1990 to less than 3% currently based on knowledge of better alternative nutrient sources. This then becomes a prelude in looking for a comparatively cheap and available source of ingredient for fish feed. This study therefore attempts to find out the comparative effects of cattle blood meal, local waste of meat and bone meal, and fishmeal on growth, survival and condition factor of Nile tilapia.

MATERIALS AND METHODS

The research was conducted using experimental fishes obtained from Little Stream Fish Farm, Uyo, Akwa Ibom State. Feed ingredients were bought from reputable Agro-Vet stores within Uyo metropolis. The experiment was carried out with males of Nile tilapia (*Oreochromis niloticus*). This was to prevent indiscriminate breeding during the experimental period since this species is known for its prolific breeding nature.

Experimental Formulation

Three diets were formulated (Table 1) from practical ingredients with blood meal (BM), meat and bone meal (MBM), and fish meal (FM) as main protein sources and designated diets 1, 2 and 3 respectively. The fourth diet (diet 4) had equal proportions (1:1:1) by weight of these protein sources. Ingredients were accurately weighed and mixed manually. A 100ml hot water (70^0C) was added and mixed. Moisten feed mixture was passed through a meat mincer with die size of 2 mm and dried in open air. Dried pellets were labeled according to diet, stored in airtight plastic bags and placed in deep freezer at - 4 °C for feeding trials.

Experimental Fish Culture

The fish (*O. niloticus*) with initial average weight 30.50g ±0.30 g were acclimated for 14 days before commencement of feeding trials. Ten (10) fish were randomly sampled and stocked in 60-litre capacity plastic troughs in closed water flow-through system with aeration. Fishes were fed 5% biomass which was divided into three portions and fed at 8.00hr, 13hr and 18hr daily for 12 weeks. Each treatment was fed in triplicate. Fish were counted and weighed fortnightly and readings obtained were used to compute growth parameters. New fish weights were used to adjust the amount of feed supplied. Leftover feed was collected by siphoning, dried and then weighed. The values were then subtracted from amount supplied to estimate feed consumption.

Proximate Analysis of Experimental Fish and Diets

Proximate analysis of feed ingredients, experimental diets, and fish carcass was done according to (AOAC, 2004). Crude protein by micro – kjeldahl method; Crude fat by soxhlet extraction; Total ash by muffle furnace combustion; Crude fiber by trichloroacetic acid method; Moisture by oven – drying to a constant weight; Carbohydrate by 100 – (% protein + % fat + % fiber + % ash + moisture) and Gross Energy using physiological fuel value of 16.7, 16.7 and 37.7kJ g-1 for protein, carbohydrates and lipid, respectively (Du *et al*., 2005).

Determination of Nutrient Utilization Parameters

$$\text{Percentage weight gain (PWG) (\%)} = \frac{(\text{Mean final weight} - \text{Mean initial weight})}{\text{Mean initial weight}} \times 100$$

$$\text{Daily weight gain (DWG) (g/day)} = \frac{(\text{Mean final weight} - \text{Mean initial weight})}{\text{Culture period (day)}}$$

$$\text{Survival rate (\%)} = \frac{(\text{Number of fish survived})}{\text{Number of fish stocked}} \times 100$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Crude Protein fed}}$$

$$\text{Apparent net protein retention (ANPR)} = \frac{\text{Final carcass protein- Initial carcass protein}}{\text{Crude protein fed}} \times 100$$

$$\text{Specific growth rate (\%/day)} = \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{T_2 - T_1} \times 100$$

Where: W_2 = Weight gain at time T_2; W_1 = Weight gain at time T_1

Condition factor (CF) of Nile tilapia was determined using the following formula:

$CF = 100W/L^3$ (Gupta and Gupta, 2010)
Where W = Weight (g) and L = Length (cm).
Feed conversion ratio (FCR) = $\frac{\text{Mean final weight–Mean initial weight}}{\text{Total feed consumed}}$

DATA ANALYSIS

The analyses were done using Statistical Package for Social Sciences (19.0), 2012 version.

Table 1: Composition (%/100g) of the experimental diets

Feed Ingredients (%)	Experimental Diets (35% crude protein)			
	D1(BM)	D2(FM)	D3(MBM)	D4(Combined)
Blood meal	24.40	-	-	10.73
Fishmeal	-	33.06	-	10.73
Meat and bonemeal	-	-	45.55	10.73
Corn flour	69.00	59.94	47.45	60.81
Binder	2.00	2.00	2.00	2.00
Fish oil	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Lysine	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Fish premix	0.50	0.50	0.50	0.50
Vitamin C	0.50	0.50	0.50	0.50

RESULTS AND DISCUSSION

Nutrient composition of ingredients: Both BM and MBM are by-products from livestock slaughter operations. The slaughter processes and conditions employed by abattoir operators in Nigeria are sufficient in destroying pathogenic microorganisms and yet able to have a minimum effect on digestibility of key nutrients. Typical compositions of FM, MBM and BM with their corresponding requirement levels by Nile tilapia are present in Table 2. From this table, and with respect to tilapia requirement, MBM values are similar to those of FM in composition. However, MBM are lower in some amino acid values but higher in minerals as compared with FM. These values suggest that MBM could be used in tilapia diet to a level similar to FM. This supports the results obtained in this study as fish fed Diet 3 (MBM) exhibited competitive growth and body composition with group fed Diet 2 (FM).

Growth performance: Gradual increase in body weight was observed in fish within the first two weeks of the trial in all treatments except for group fed blood meal diet which showed insignificant growth (Figure 1). This may have been that fish needed to adapt to the unpalatability nature of blood meal. This was in line with the report of El-Sayed (1998) that the level of blood meal used in diets has been severely limited, mainly because of problems of palatability and poor growth rate and that all these problems relate to inherent amino acid imbalance and also to low digestibility induced by overheating of the blood during processing. Results of mean growth parameters and nutrient utilization are presented in Table 3. From these results, fish fed MBM compared effectively with those fed pure FM diet but Protein Productive Value (PPV), Food Conversion (FCR) and Protein Efficiency (PER) ratios were higher in group fed MBM diet. This contradicts the findings of El-sayed (1998) who observed similar growth and lower FCR and PER and Yu (2004) who recommended 60% replacement rate of MBM. The reason for this variation may not be unconnected to batch differences and different methods adopted in processing of these meals. Survival was similar ($p > 0.05$) in all treatments and highest (63.33%) in group fed BM diet indicating that tilapia could survive far beyond 6% level of blood meal inclusion reported by Ogunji and Wirth (2001) and 10% incorporation

reported by Bekibele *et al* 2013. Similar successes were reported by Watanabe *et al* (1998) and Meyer and Fracalossi (2004) who fed 50-75% spray-dried blood meal to tilapia and up to 100% to jundia fingerlings respectively. When diet containing equal ratio (1:1:1) of FM, BM and MBM was fed to tilapia, mean weight gain, daily growth rate, protein productive value, and specific growth rate were higher than values observed in group fed pure fishmeal diet but FCR and PER were similar ($p > 0.05$). This supports the report of Kader *et al* (2011) when they combined fishmeal, protein concentrate and meat and bone meal in equal ratio on diet of climbing perch. From the results of this study, it appeared that Nile tilapia could use MBM diets containing up to 100% inclusion level without the reduction in final mean weight, survival, and FCR. Furthermore, there were no negative effects of using MBM as a protein source; therefore, it is possible to rear tilapia using this meal as the primary protein source without growth reduction or requiring synthetic amino acid supplementation. However, caution should be exercised when using relatively high levels (>10%) of BM in tilapia feed for water quality consideration and unless the diet is to be supplemented with synthetic amino acid as observed in this study. Condition factor (K) was higher than 1 in all classes of fish. This could mean that fish reared in indoor flow-through system and fed diets containing fishmeal, meat and bone meal and blood meal alone and in combination were in good and healthy conditions. This could also mean that the growth of these fish was good as condition factor has been used as an index for growth studies (Gupta and Gupta, 2010).

Nutritional status of experimental fish: From Table 4, the observed range of ash content indicated that tilapia was a good source of minerals such as calcium, potassium, zinc, iron and magnesium. Gross energy values of treated fish were significantly higher ($p < 0.05$) than those at the start of the experiment with significant differences between groups. Moisture, lipid and protein contents were within previously reported range in other fishes (NRC, 1993) in all tested groups.

Table 2**:** Proximate Composition, Amino Acid Profile and Tilapia Requirement of Fishmeal, meat and bonemeal, and bloodmeal (% dry matter).

Parameters	FM*	MBM*	BM*	Tilapia Requirement
Main Analysis				
CP	72.0	54.9	94.1	20-45
Ether extract	11.0	12.1	1.8	6.0-8.0
Ash	13.6	30.5	3.0	-
Crude Fibre	-	-	0.5	-
Gross energy	21.9	17.7	24.1	-
Minerals				
Calcium	26.5	10.1	1.3	7.0-7.5
Phosphorus	22.3	48.7	2.2	< 9.0
Potassium	11.9	4.6	3.8	2.0-3.0
Magnesium	3.1	2.2	0.2	0.59
Amino Acid				**
Arginine	5.8	6.9	4.2	4.20
Histidine	2.2	2.1	6.2	1.72
Isoleucine	4.3	2.9	1.1	3.11
Leucine	7.0	6.0	12.1	3.39
Lysine	7.5	5.0	8.7	5.12
Methionine	2.8	1.3	1.2	2.68
Phenylalanine	3.8	3.4	6.9	3.75
Threonine	4.1	3.3	4.7	3.75
Tryptophan	1.1	0.6	1.4	1.00
Valine	4.9	4.4	8.5	2.80

Sources: El-Sayed, 1998; Watanabe *et al* (1998)

Table 3: Summary of growth performance and condition factor of Nile tilapia fed diets containing fishmeal, meat and bonemeal, and bloodmeal alone and in combination for 12 weeks.

	Experimental Diets			
Parameters	BM	FM	MBM	CMB
Initial wt	30.50±0.00	30.50±0.00	30.50±0.00	30.50±0.00
Final wt	345.47±0.38^{a}	384.43±0.53^{b}	352.80±3.97^{c}	398.77±1.44^{d}
MWG	314.97±0.38^{a}	353.93±0.53^{b}	322.30±3.97^{c}	368.29±1.44^{d}
DWG	3.75±0.00^{a}	4.21±0.00^{b}	3.84±0.05^{c}	4.39±0.02^{d}
Food Fed	44.17±0.07^{a}	49.20±0.06^{b}	42.03±0.38^{c}	51.03±0.12^{c}
CP Fed	12.90±0.00^{a}	15.10±0.00^{b}	12.33±0.12^{c}	15.67±0.03^{d}
FCR	7.13±0.00^{a}	7.19±0.00^{b}	7.67±0.03^{c}	7.22±0.01^{b}
PER	24.41±0.03^{a}	23.44±0.04^{b}	26.13±0.12^{c}	23.51±0.06^{b}
SGR	2.89±0.00^{a}	3.01±0.00^{b}	2.91±0.00^{a}	3.06±0.01^{d}
PPV	18.29±0.01^{a}	65.75±0.01^{b}	68.05±0.01^{c}	76.60±0.00^{d}
K	2.57±0.01^{a}	2.00±0.01^{b}	2.40±0.07^{c}	2.04±0.01^{d}
Survival	63.33±1.67^{a}	61.00±2.08^{a}	61.00±0.00^{a}	60.33±2.60^{a}

All values are mean values ± standard error of mean of 3 observations. Means in the same row with the same superscript were not significantly different ($p > 0.05$). Where: MWG: Mean weight gain; DWG: Daily weight gain; FCR: Food conversion ratio; PER: Protein efficiency ratio; SGR: Specific growth rate; PPV: protein productive value; K: Condition factor.

Table 4: Nutritional analysis of fillet (% dry weight) of experimental fish

Indices	Initial	BM	FM	MBM	CMB
Moisture	77.50^{e}	72.0±0.12^{a}	73.50±0.1^{c}	75.65±0.3^{d}	72.81±0.2^{c}
Ash	5.11^{d}	4.79±0.07^{c}	4.45±0.1^{b}	3.94±0.1^{a}	4.77±0.2^{c}
Fibre	0.03^{a}	0.20±0.00^{c}	0.02±0.00^{a}	0.31±0.01^{a}	0.18±0.05^{b}
Protein	11.90^{a}	15.31±0.61^{c}	14.92±0.03^{b}	14.48±0.09^{b}	15.28±0.22^{c}
Lipid	5.40^{a}	5.68±0.07^{d}	5.54±0.08^{b}	5.31±0.15^{a}	5.61±0.18^{c}
Carbohydrate	0.06^{a}	2.02±0.20^{e}	1.59±0.23^{d}	0.32±0.23^{b}	1.40±0.07^{c}
Calorie (kJ/g)	4.04^{a}	5.04±0.8^{d}	4.85±0.3^{c}	4.47±0.7^{b}	4.90±0.5^{c}

*Values are given as mean of triplicate experiments.

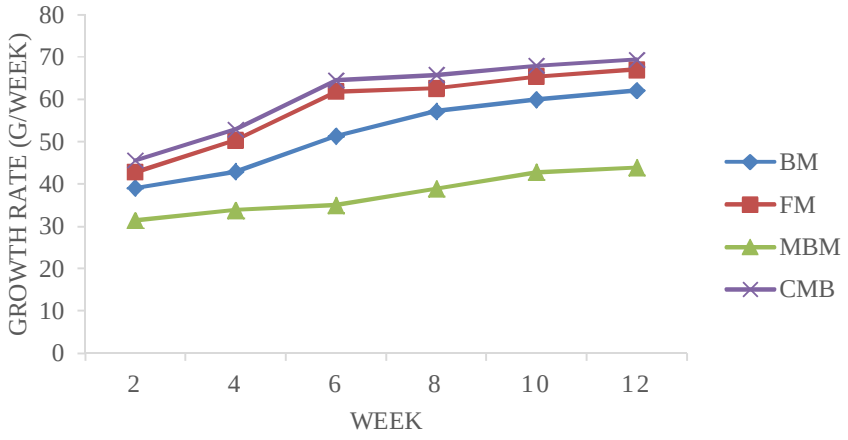

Figure 1: Growth curve of Nile tilapia fed diets containing different animal protein sources for 12 weeks showing biweekly growth rate.

CONCLUSION

The study showed that meat and bonemeal can compete favourably with fishmeal in tilapia nutrition with no detrimental effect on survival and protein utilization. However, a mixture of equal proportion of fishmeal, bloodmeal and meat and bonemeal produced the best result.

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